CLAIMS

1. An extended rich mode engine having an intake and an exhaust, said extended rich mode engine configured to operate extremely rich of stoichiometric to produce a substantially continuous hydrogen rich engine exhaust.

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2. An extended rich mode engine as in claim 1, wherein said engine is configured to produce a hydrogen rich engine exhaust having a combined concentration of hydrogen and carbon monoxide greater than about 30% by volume.

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3. An extended rich mode engine as in claim 1, wherein said engine is configured to produce a hydrogen rich engine exhaust having a combined concentration of hydrogen and carbon monoxide greater than about 50% by volume.

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4. An extended rich mode engine as in claim 1, further comprising an oxygen enrichment device having an oxygen stream effluent in fluid communication with said engine intake.

5. An extended rich mode engine as in claim 4, wherein said oxygen enrichment device is an oxygen separator, a pressure swing absorption oxygen separator, a SOFC oxygen separator, a ceramic membrane oxygen separator, or a combination thereof.

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6. An extended rich mode engine as in claim 4, wherein said hydrogen rich engine exhaust has a combined concentration of hydrogen and carbon monoxide greater than about 70%.

7. An extended rich mode engine as in claim 1, wherein said extended rich mode engine is an internal combustion engine.

8. An extended rich mode internal combustion engine as in claim 7, further comprising an oxygen enrichment device having an oxygen stream effluent in fluid communication with said engine intake.

9. An extended rich mode internal combustion engine as in claim 8, wherein said oxygen enrichment device is an oxygen separator, a pressure swing absorption oxygen separator, a SOFC oxygen separator, a ceramic membrane oxygen separator, or a combination thereof.

10. An extended rich mode internal combustion engine as in claim 7, further comprising a rich homogenous charge compression ignition.

11. An extended rich mode internal combustion engine as in claim 7, further comprising an oxygen enrichment device, a rich homogenous charge compression ignition, an optional dilute cylinder system in part of said engine, and combinations thereof.

12. An extended rich mode internal combustion engine as in claim 7, comprising a spark ignition internal combustion engine.

13. An extended rich mode spark ignition internal combustion engine as in claim 12, further comprising an oxygen enrichment device having an oxygen stream effluent in fluid communication with said engine intake.

14. An extended rich mode spark ignition internal combustion engine as in claim 13, wherein said oxygen enrichment device is an oxygen separator, a pressure swing absorption oxygen separator, a SOFC oxygen separator, a ceramic membrane oxygen separator, or a combination thereof.

15. An extended rich mode internal combustion engine as in claim 7, comprising a compression ignition internal combustion engine.

16. An extended rich mode compression ignition internal combustion engine as in claim 15, further comprising an oxygen enrichment device having an oxygen stream effluent in fluid communication with said engine intake.

17. An extended rich mode compression ignition internal combustion engine as in claim 16, wherein said oxygen enrichment device is an oxygen separator, a pressure swing absorption oxygen separator, a SOFC

oxygen separator, a ceramic membrane oxygen separator, or a combination thereof.

18. An extended rich mode engine as in claim 1, wherein said engine comprises a free piston gas generator.

19. An extended rich mode free piston gas generator as in claim 18, further comprising a rich homogenous charge compression ignition.

20. An extended rich mode free piston gas generator as in claim 19, further comprising an oxygen enrichment device having an oxygen stream effluent in fluid communication with said engine intake.

21. An extended rich mode free piston gas generator as in claim 20, wherein said oxygen enrichment device is an oxygen separator, a pressure swing absorption oxygen separator, a SOFC oxygen separator, a ceramic membrane oxygen separator, or a combination thereof.

22. An extended rich mode engine as in claim 1, wherein said engine comprises an extremely rich inlet turbo-generator system.

23. An extremely rich inlet turbo-generator system as in claim 22, wherein said extremely rich inlet turbo-generator system is selected from the group consisting of a turbo-generator system having a two stage combustor and a turbo-generator system having a single stage combustor.

24. An extremely rich inlet turbo-generator system as in claim 22, further comprising an oxygen enrichment device having an oxygen stream effluent in fluid communication with said engine intake.

25. An extremely rich inlet turbo-generator system as in claim 24, wherein said oxygen enrichment device is an oxygen separator, a pressure swing absorption oxygen separator, a SOFC oxygen separator, a ceramic membrane oxygen separator, or a combination thereof.